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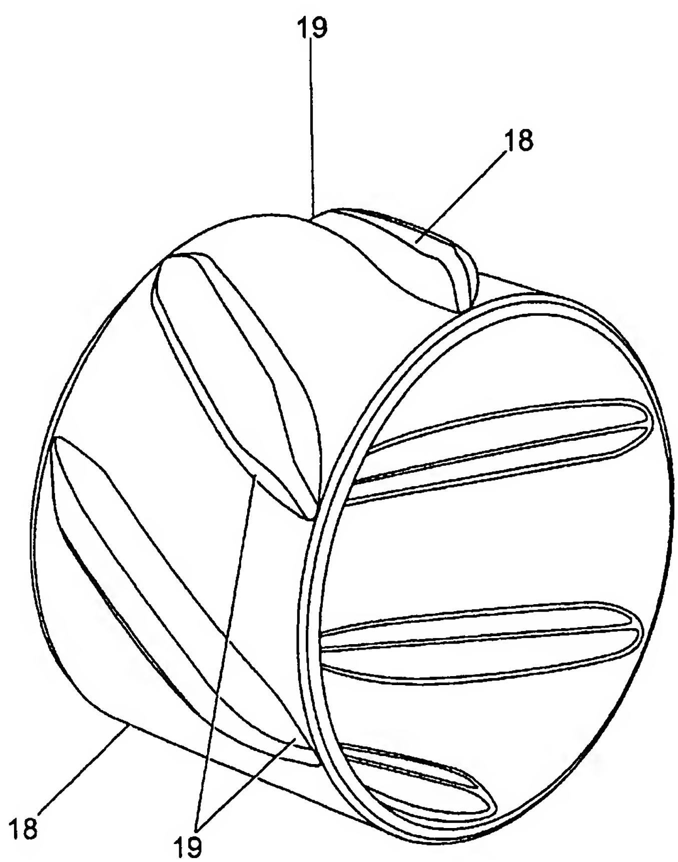
(54) Title: CENTRALISER



(57) Abstract: A centraliser for use in centralising casing or other tubulars such as tubulars in an oil or gas well comprising an annular body with a bore extending through the body and one or more blades, the centraliser being adapted to fit around a tubular to be centralised, and comprising a tempered metal such as austemperised ductile iron (ADI).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

"Centraliser"

This invention relates to a centraliser, and particularly to a centraliser for use in centralising casing or other tubulars such as drillpipe or screens in an oil or gas well.

In drilling wellbores for oil and gas it is common to drill through the formation and subsequently to case the open bore with a liner or a casing (typically of metal) and to cement the liner or casing in place. Centralisers are used around the liner or casing in order to keep it in the middle of the borehole and to allow free flow of cement through the annulus between the casing and the wall of the borehole. This acts as a sealant and also as a mechanical support for the casing. Centralisers have therefore been adapted for attachment around the outer diameter of a liner or casing prior to the cement job. Centralisers can also be used to keep a screen in a central location in the wellbore as it passes through a formation.

According to the present invention there is provided a centraliser comprising an annular body with a bore extending through the body and one or more blades, the centraliser being adapted to fit around a tubular to be centralised, and comprising a tempered metal.

The invention also provides a method of manufacturing a centraliser, the method comprising forming the centraliser from metal and tempering the metal centraliser.

The metal is preferably austenitised, typically by heating the metal to 800-960°C typically for 1 to 4 hours. Preferably the metal is also austempered by quenching in molten salt for 2-4 hours at 200-400°C and preferably air dried. Preferably the salt is a mixture of potassium nitrate and sodium nitrite. Typically an equimolar mixture of these salts is used. Typically the entire centraliser is formed from the tempered metal. Any other tempering process can be used to temper the metal. Suitable methods can be found in Metals Handbook Vol 1-3 1990-1991 published by ASM International.

The metal is preferably ductile metal and most preferably comprises ductile iron, although any metal that can be tempered will suffice. Castable metals are preferred.

Alloys can be used as the metal of the centraliser, and in particular, iron can be alloyed with Mo, Cu or Ni to enhance the hardness of the metal.

The iron is normally a cast iron with preferably 3.2-3.8% C (most preferably around 3.6% C) and 2.2-2.8% Si (most preferably around 2.5%). Typically other alloying elements are added in very small quantities (<0.04%) which may include Mg, Mn, Cu, Ni, Mo, Sn, Sb, P, S, O, Cr, Ti, V, Al, As, Bi, B, Cd, Pb, Se, Te. Elements such as Be, Ca, Sr, Ba, Y, La, Ce may be added in lieu of, or in addition to, Mg.

Grades 1-5 of ADI are preferred according to ASTM 897M-90.

The centraliser is typically cast into the desired shape with the annular body and blades, optionally shaped e.g. by filing or grinding, and then tempered, e.g. by austempering the whole centraliser. The tempering process can be extended in accordance with the ratio of ferrite:pearlite in the metal. Metals with a higher ferrite:pearlite ratio may need longer tempering process times. The centraliser is typically cast in a slightly different shape (e.g. with an oval-shaped annular body) to that of the final product (e.g. a cylindrical annular body) to allow for distortions occurring during the casting and tempering process. Typically the centraliser shrinks by e.g. 1-2% during casting and typically expands by e.g. 1-2%

after heat treatment. Therefore the centraliser is typically cast to a different size than finally required.

The blades are preferably circumferentially distributed around the outer surface of the centraliser, and preferably each extends parallel to the bore of the centraliser. The blades are preferably disposed opposite one another on the centraliser body. There may be four, five or six such blades or some other number.

The method of the invention is typically carried out by high-temperature casting in a sand casting mould. The blades of the centraliser are typically formed between indentations in the mould and protrusions on a blank set in the mould. The blade shapes are typically profiled to facilitate removal of the cast centraliser from the mould, and are typically profiled differently from one another. The centraliser is typically formed by two half-moulds adapted to engage one another so as to form the centraliser between the two half-moulds. Typically the join between the two moulds is aligned with a blade of the centraliser.

The tubular can be drillpipe, casing, liner, production tubing, coil tubing and may include slotted and predrilled and/or plugged tubing, screens and perforating strings etc for disposal in the reservoir payzone, in which case the centraliser

would maintain the screen in the middle of the uncased borehole.

An embodiment of the invention will now be described by way of example and with reference to the accompanying drawings in which:-

Fig. 1 is a front elevation of a centraliser;

Fig. 2 is a side perspective view of the Fig. 1 centraliser;

Fig. 3 is a plan view of the Fig. 1 centraliser; and,

Fig. 4 is a perspective exploded view of a sand cast used to manufacture the Fig. 1 centraliser.

A casing centraliser 10 comprises a unitary moulded cylindrical body 12, and an array of six equiangularly-spaced blades 14 integrally formed with the body 12. A cylindrical bore 16 extends axially through the body 12, and has a substantially uniform diameter dimensioned to be a clearance fit around the well bore casing, or other tubular to which the centraliser is applied.

Each of the blades 14 not only extends between longitudinally opposite ends of the body 12, but also extends circumferentially around the periphery of the centraliser 10. The skewing of the blades 14 ensures that their respective outer edges 18

collectively provide a generally uniform well bore-contacting surface around the circumference of the centraliser 10.

Each of the blades 14 has a respective radially inner root 19 integral with the body 12. In each of the blades 14, the root 19 has a greater circumferential width than the outer edge 18, i.e. the cross-section of each blade 14 tapers towards the well bore-contacting periphery of the centraliser 10. The individual and collective shapes of the blades 14, and of the longitudinal fluid flow passages defined between adjacent pairs of the blades 14, gives the centraliser 10 improved flow characteristics and minimises the build-up of trapped solids during use of the centraliser 10. The tapered cross-section of the blades also eases removal of the centraliser from the cast during manufacture.

Longitudinally opposite ends of the blades 14 and of the body 12 are chamfered to assist in movement of the centraliser 10 up/down a well bore.

The blades 14 of the centraliser 10 keep the tubular centralised within the borehole, and bear against the wall of the borehole to reduce friction should the tubular be moved.

It is preferred that the entire centraliser 10 be fabricated as a one-piece article (although the blades 14 could be separately formed and

subsequently attached to the body 12 by any suitable means). The centraliser 10 is typically formed from ductile iron and moulded in a sand cast 20.

The sand cast 20 is used to cast mould the centaliser 10. The sand cast 20 is made up from two parts 21a, 21b with semi-circular cross section.

An indent 22 to correspond to the outer face of the centraliser 10 is first cut out from the sand 25 in each part 21a, 21b of the cast 20. Further indentations are then cut into the indent 22 to form outer faces of blades 14 in the cast centraliser. An inner core 23 is secured in support holes 24 to act as a blank and is suspended in the indent 22 without touching the walls thereof so as to displace metal from an axial bore of the centraliser 10 and provide on its outer surface a blank for the inner surface of the centraliser 10. The core 23 is therefore located in the mould where the bore 16 of the centraliser will be in the finished article. The upper cast 21b is joined to the lower cast 21a before the metal is poured so that the complete shape cut out of the sand 25 is that of the centraliser 10. Normally the join between the upper 21b and lower 21a parts of the cast are aligned with or are close to a blade 14.

As the material will shrink on cooling and its dimensions will be altered during heat treatment, the shape of the indent 22 can first be precisely determined from shrinkage calculations and by

measurements of previous casts. The material being moulded will also affect the shrinkage characteristics. Typically the centraliser will expand during the tempering process. As the shrinkage after casting and particularly the expansion after tempering, is non-uniform a specifically calculated indent 22 is used to make the centraliser 10. We find that ductile iron shrinks by about 1-2% when cooling in the cast, and expands by about 1-2% when being tempered.

The sides of the indent 22 curve inwards to allow the mould to be removed from the centraliser after the material has solidified. The blades 14 are tapered to ease the removal of the centraliser 10 from the mould.

Molten ductile iron is poured through the hole 26 and into the indent 22. The iron is allowed to cool and so the centraliser 10 is formed. The sand cast 20 can then be removed from the centraliser 10. The tapered sides of the indent 22 and tapered blades 14 allow the cast to be removed relatively easily.

The iron is normally a cast iron with between 3.2-3.8% C (most preferably 3.6% C) and 2.2-2.8% Si (most preferably 2.5%). C and Si to an extent, encourage similar properties in the material and so the sum of %C, and (1/3) %Si can be considered as a *carbon equivalent(CE)*. The total CE ranges are typically around 4.3% for thick sections (over 2"),

to 4.6% for thin sections, (0.1″-0.5″), but other values can be used.

Optionally other alloying elements are added in very small quantities which may include Mn(typically 0.35-0.60%), Mg ((%S x 0.76) + 0.025% +/- 0.005%), Sn (0.02 +/-0.003%), Sb (0.002% +/- 0.0003%), P (0.04%), S (0.02%), O (50ppm), Cr (0.10%), Ti(0.040%), V (0.10%), Al (0.050%), As (0.020%), Bi (0.002%), B (0.002%), Cd (0.005%), Pb (0.002%), Se (0.030%), and/or Te (0.020%).

To increase hardenability for a heavier section (i.e. greater than 19mm), Cu(up to 0.8%), Ni(up to 2%) and Mo(up to 0.3%) may be added. Increased hardenability helps to prevent the formation of pearlite during quenching. Mg is added to encourage nodulisation. Elements such as Be, Ca, Sr, Ba, Y, La, Ce may be added in lieu of or in addition to Mg. The total weight of nodulising elements is not normally more than about 0.06%.

The castings should be free of non-metallic inclusions, carbides, shrink and dross. Proper purchasing, storage and use of charge material will minimise the unwanted occurrence of carbides and gas defects. Proper moulding control will minimise surface defects and other sub-surface discontinuities. The casting should be properly gated and poured using consistent and effective treatment and inoculation techniques to ensure shrink free castings. Preferably the nodule count

will be at least $100/mm^2$ and the nodularity at least 85%.

After casting the centraliser 10 is tempered by a heat treatment to produce a stronger, harder material. The ductile iron used to produce the centraliser 10, normally contains pearlite and ferrite which are irregular in shape and vary substantially in size. This reduces hardness and strength. The centraliser is heated to the austenite phase i.e. between 815°C and 955°C depending on the precise concentration of the alloys. The centraliser is held for 1-4 hours in the austenite phase, the precise time required depends on the size of the centraliser and the amount of ferrite in the metal; a higher concentration of ferrite may require more time at these elevated temperatures. When the austenite is saturated with carbon the centraliser is then austemperised. To achieve this the metal is quenched in molten salt at 240°C - 400°C. The rate of cooling should be sufficient to avoid the formation of ferrite or pearlite. The metal is held in the salt for 1-4h to allow the austenite to change to ausferrite. The molten salt is normally an equimolar mixture of potassium nitrate/sodium nitrite although other salts may be used.

The net effect of the heat treatment is to cause the ferrite and pearlite phases to be converted into ausferrite. Ausferrite is a stabilised carbon enriched austenite and acicular ferrite non-

equilibrium phase. The resulting material is termed austemperised ductile iron (ADI).

This material is twice as strong as conventional ductile iron. Another advantage is that this material is less dense than conventional steel and so is up to 10% lighter. A further advantage is the increased hardenability compared with steel. The cost of manufacturing in this way is also reduced.

Alternatively, other heat treatments may be used to adapt the microstructure and phase composition of the metal 22.

For example to increase ductility the material may be heated up to 700-730°C. After 1-4 hours the material is quenched in molten salt. This reduces the amount of coarse pearlite and increases the amount of spheriodite in the structure.

A further alternative may be to anneal the steel. The centraliser is again heated into the austenite phase but is then allowed to cool gradually. This produces a microstructure with small and uniform grains.

Modifications and improvements can be incorporated without departing from the scope of the invention.

Claims

1. A centraliser comprising an annular body with a bore extending through the body and one or more blades, the centraliser being adapted to fit around a tubular to be centralised, and comprising a tempered metal.

2. A centraliser as claimed in claim 1, wherein the centraliser is made substantially from a tempered metal.

3. A centraliser as claimed in any preceding claim, wherein the metal is ductile iron.

4. A centraliser as claimed in any preceding claim, wherein the tempered metal is austemperised ductile iron.

5. A centraliser as claimed in any preceding claim, wherein the metal comprises 3.2-3.8wt% C and/or 2.2-2.8wt% Si.

6. A centraliser as claimed in any preceding claim, wherein the metal is alloyed with at least one of Mo, Cu and Ni.

7. A centraliser as claimed in any preceding claim, wherein the metal is alloyed with at least one of Mg, Mn, Sn, Sb, P, S, O, Cr, Ti, V, Al, As, Bi, B, Cd, Pb, Se, Te, Be, Ca, Sr, Ba, Y, La, and Ce.

8. A centraliser as claimed in any preceding claim, wherein the blades are circumferentially distributed around the outer surface of the centraliser, each extending parallel to the bore of the centraliser.

9. A method for manufacturing a centraliser, the method comprising forming a centraliser from metal and tempering the metal centraliser.

10. A method as claimed in claim 9, wherein the centraliser is a centraliser as claimed in any one of claims 1 to 8.

11. A method as claimed in claim 9 or claim 10, wherein the method comprises the steps of:-

heating a ductile iron centraliser to a first temperature at which austenite is formed;

maintaining the centraliser at said temperature; and

cooling the centraliser to room temperature.

12. A method as claimed in claim 11, wherein the method also includes cooling the centraliser from the first temperature to a second temperature at which austemperising may take place, before cooling the centraliser to said room temperature.

13. A method as claimed in claim 12, wherein the centraliser is quenched from the first temperature to the second temperature.

14. A method as claimed in any one of claims 11 to 13, wherein the centraliser is cooled at a rate sufficient to combat the formation of ferrite and pearlite.

15. A method as claimed in any one of claims 9 to 14, wherein at least some of the steps are performed in a sand casting mould.

16. A method as claimed in claim 15, wherein the blades of the centraliser are formed between indentations in the mould and protrusions on a blank set in the mould.

17. A method as claimed in claim 15 or 16, wherein the blade shapes are profiled to facilitate removal of the cast centraliser from the mould.

18. A method as claimed in any one of claims 15 to 17, wherein the join between the two moulds is aligned with a blade of the centraliser.

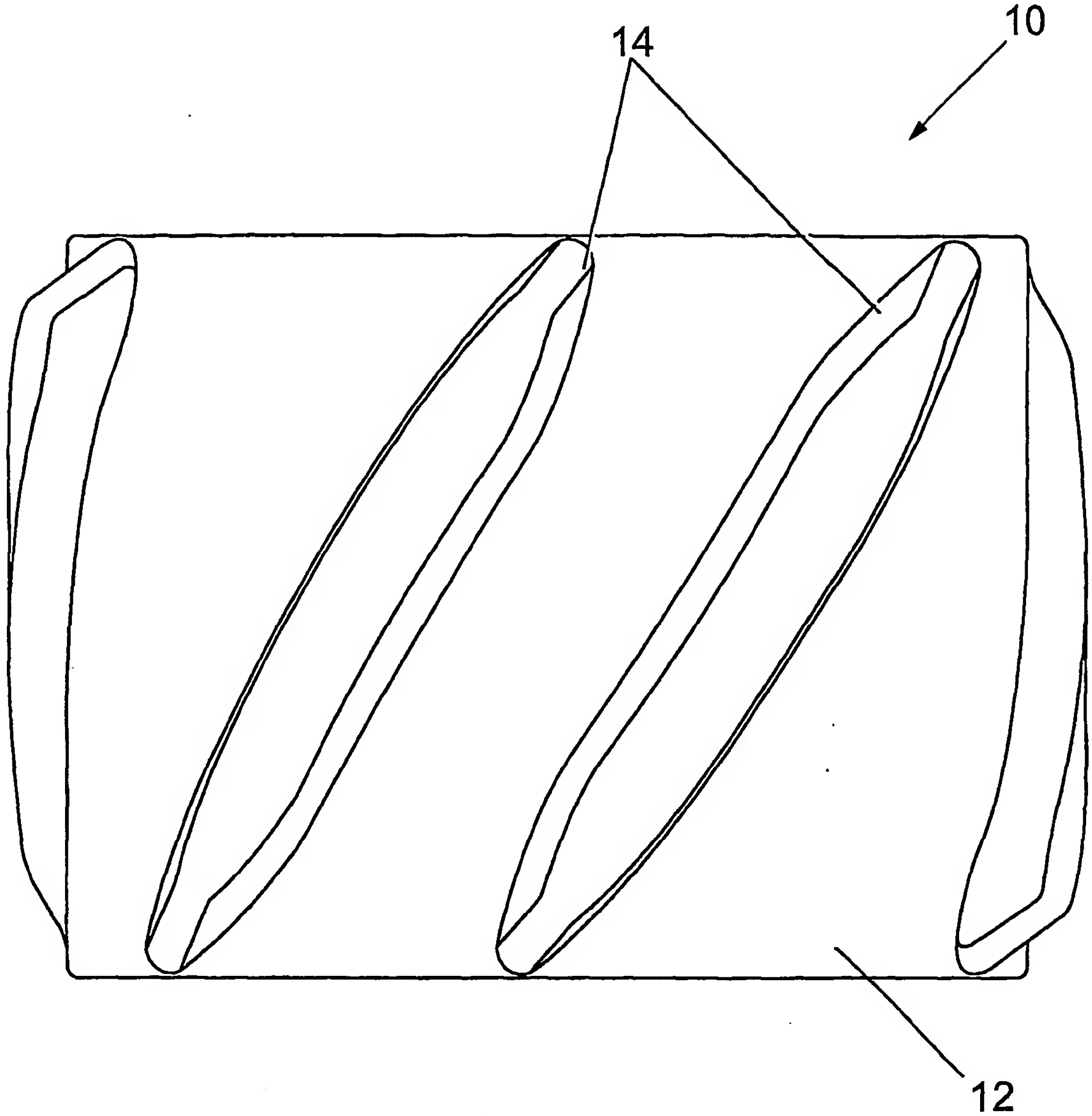

Fig. 1

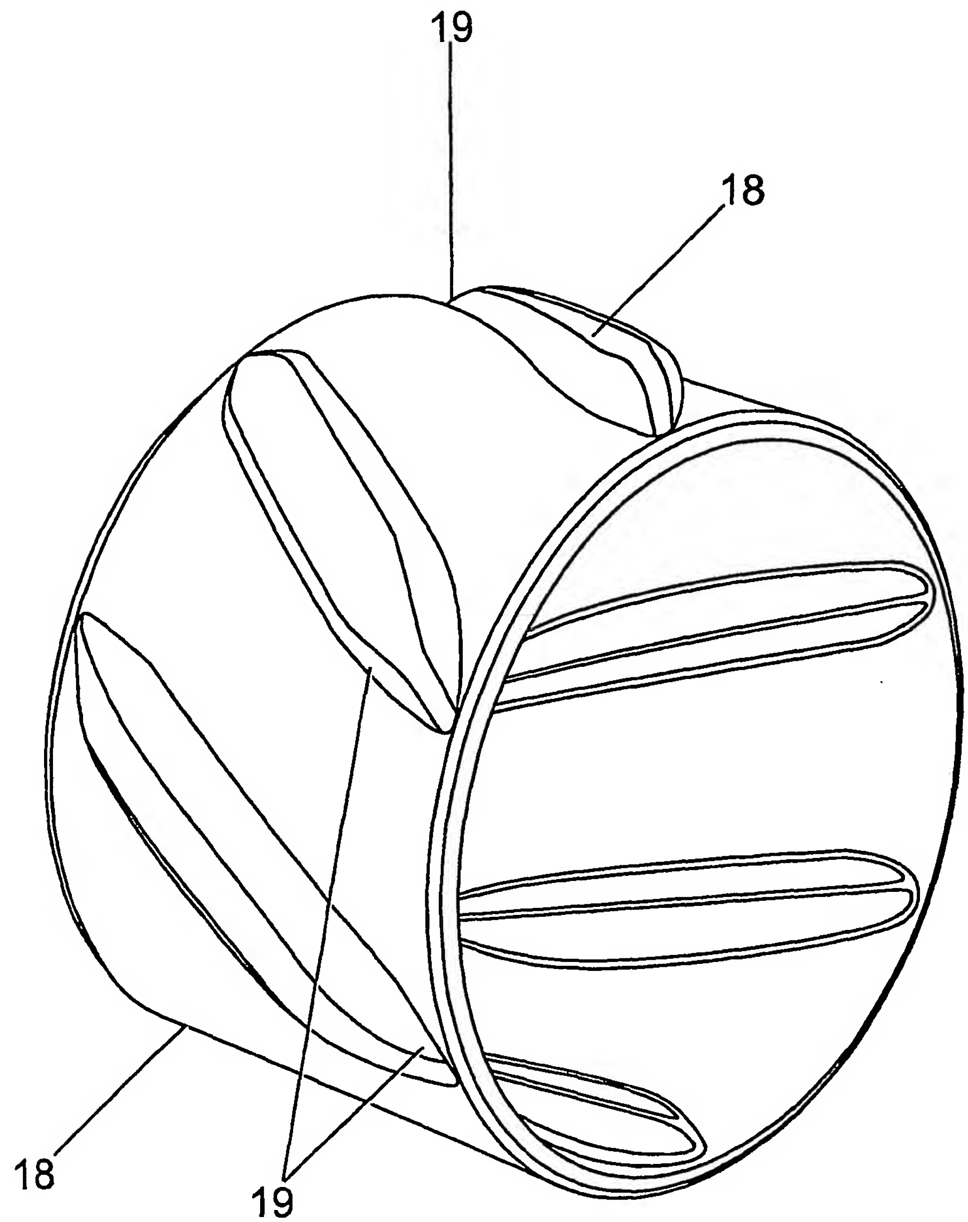

Fig. 2

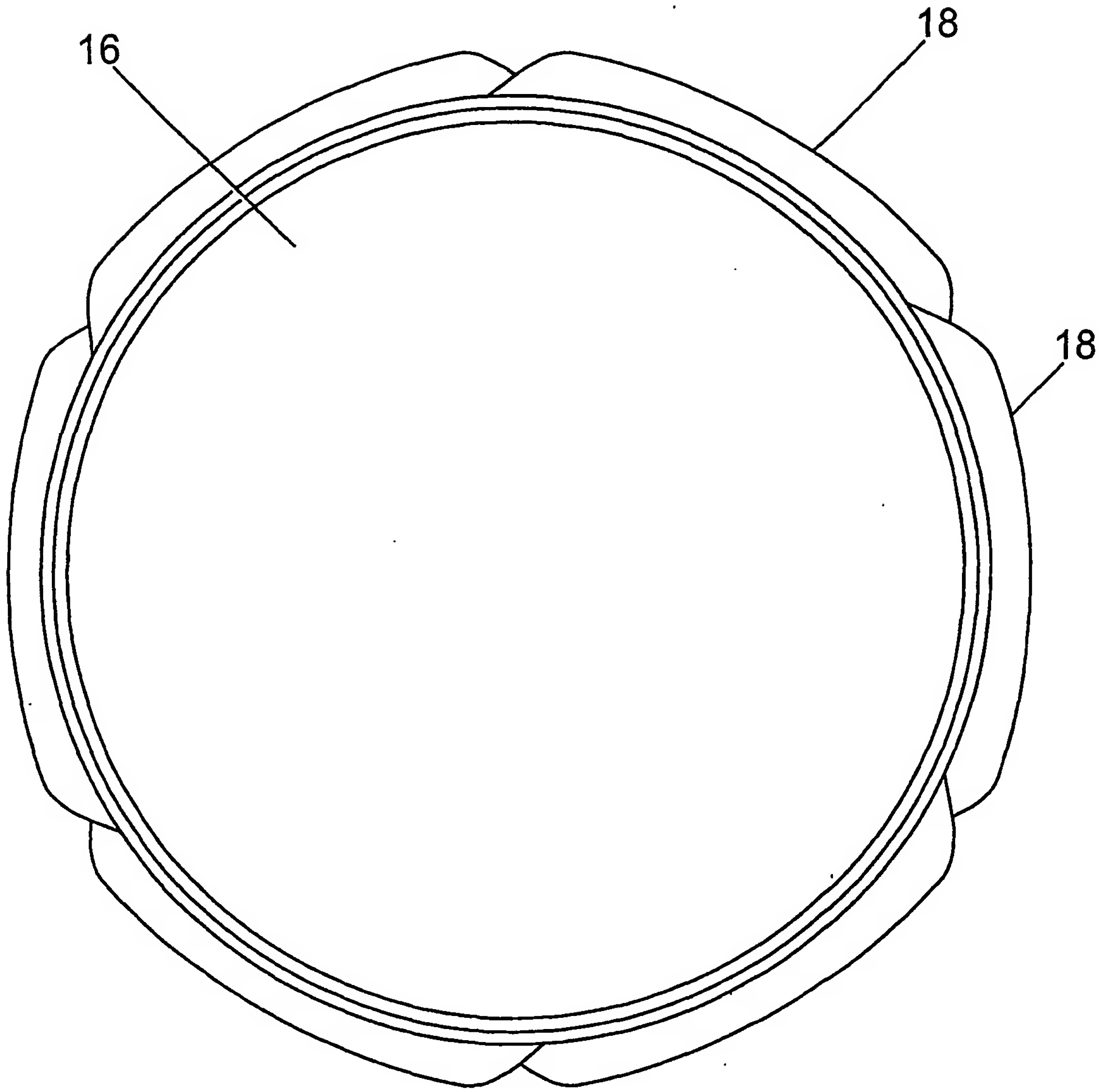

Fig. 3

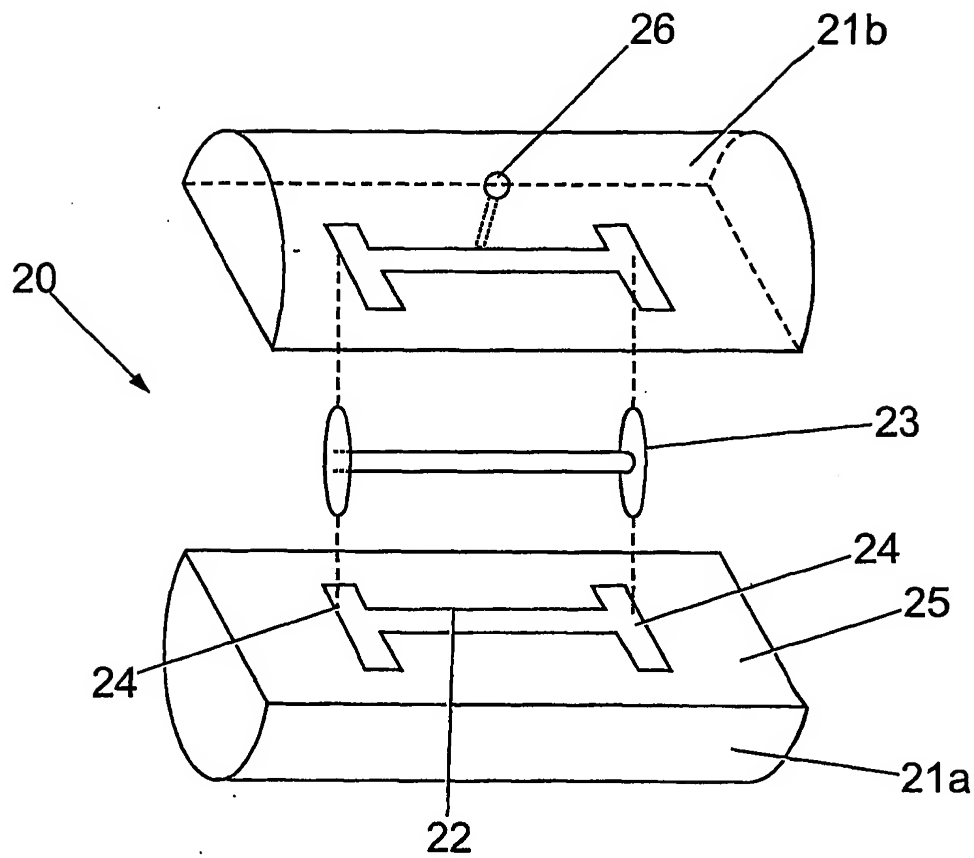

Fig. 4

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B17/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 095 981 A (MIKOLAJCZYK) 17 March 1992 (1992-03-17) abstract	1-15,17
Y	US 4 664 206 A (BUTLER) 12 May 1987 (1987-05-12) column 2, line 54 - line 57	1-15,17
A	US 5 937 948 A (ROBBINS) 17 August 1999 (1999-08-17) abstract	1,9

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Rampelmann, K

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